



Rewarding Learning

ADVANCED
General Certificate of Education
2025

Centre Number

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Candidate Number

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Life and Health Sciences

Assessment Unit A2 3

assessing

Medical Physics

MV18

[AZ031]

MONDAY 9 JUNE, AFTERNOON

Time

1 hour 45 minutes, plus your additional time allowance.

Instructions to Candidates

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.

You must answer the questions in the spaces provided.

Do not write on blank pages.

Complete questions in black ink and use a dark HB pencil for drawings and graphs.

Do not write with a gel pen.

Answer **all nine** questions.

Information for Candidates

The total mark for this paper is 100.

Figures in brackets printed at the end of each question indicate the marks awarded to each question or part question.

You may use a scientific calculator.

Quality of written communication will be assessed in question **3**.

1 (a) Pneumonia is a term used to describe an infection in the lungs.

One of the main tests used to diagnose pneumonia is a chest X-ray.

(i) X-rays are transverse waves which can transfer energy.

State two other properties of X-rays. [2 marks]

1. _____

2. _____

Pneumonia causes liquid build-up within the lungs.

(ii) Describe fully how a doctor can use an X-ray image to diagnose pneumonia. [4 marks]

(b) Medical grade X-rays are produced using an X-ray tube.

- (i)** Explain the purpose of each of the following parts of the X-ray tube in producing medical grade X-rays.
[3 marks]

Metal filament _____

High voltage supply _____

Metal target _____

- (ii)** The metal often used for the target is tungsten.
Suggest a reason why tungsten is used. [1 mark]

X-rays of various energies are produced in the X-ray tube.

- (iii)** How are medical grade X-rays selected?
[2 marks]

The components in the X-ray tube are housed in a glass envelope which contains a vacuum.

(iv) Why is it necessary to have a vacuum in the X-ray tube? [1 mark]

During X-ray production, the metal target heats up.

(v) State **one** method by which heat is removed from the metal target. [1 mark]

(c) Prolonged X-ray exposure can cause cell damage. A radiographer working in a hospital can be exposed daily to a large dose of X-rays.

(i) Describe how X-rays cause cell damage. [1 mark]

(ii) State **one** method radiographers can use to protect themselves from too much X-ray exposure. [1 mark]

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(Questions continue overleaf)

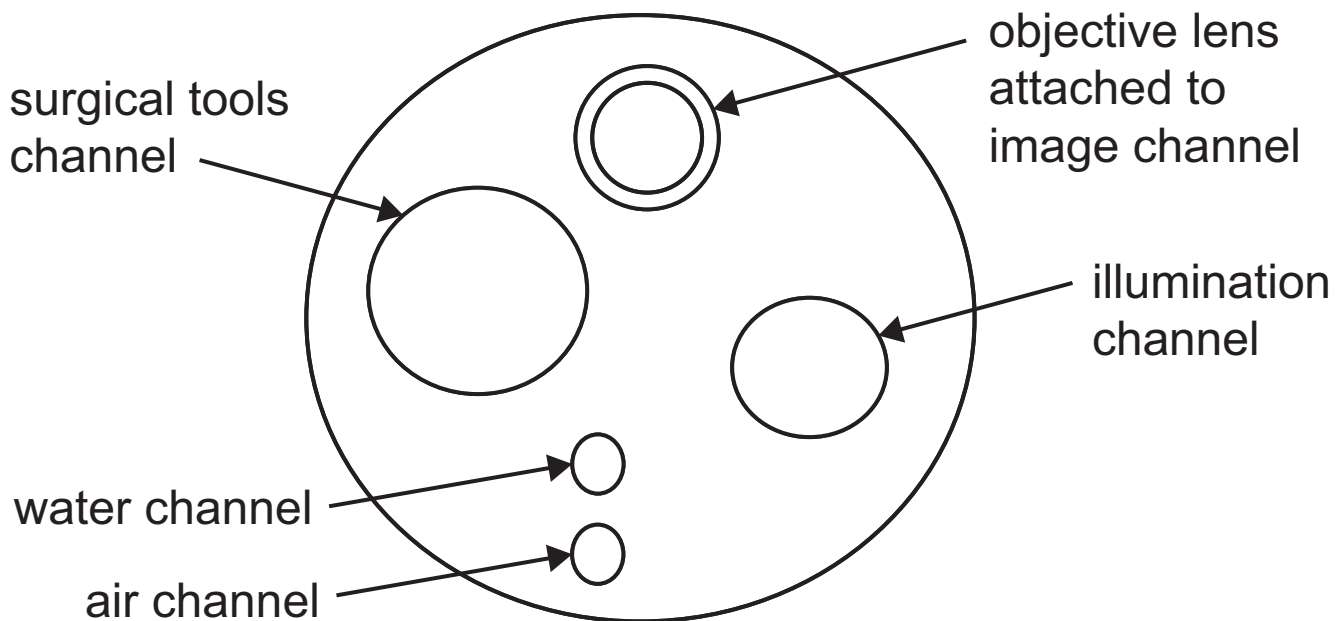
2 An endoscope can be used to examine the bladder without surgery.

(a) Suggest two advantages of having an endoscopic scan compared to investigative open surgery. [2 marks]

1. _____

2. _____

(b) Below is a labelled sketch showing the tip of the endoscope and some of its channels.



Light travels through the endoscope using optical fibres.

(i) What is the physical principle by which light travels through the full length of the optical fibre?
[1 mark]

(ii) Outline the difference between the arrangement of the optical fibres in the illumination channel and the image channel.

Explain why this difference is necessary.

[3 marks]

The objective lens is attached to the end of the image channel.

(iii) What is the purpose of the objective lens?

[1 mark]

A laser can be inserted into the tools channel for use in an endoscopic procedure.

(iv) Suggest one use of a laser in an endoscopic procedure. [1 mark]

(v) Why does the tip of the endoscope have a water channel? [1 mark]

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(Questions continue overleaf)

3 The two different particles that can be emitted from the nucleus of a radioactive material are alpha and beta.

Write a short paragraph on the properties of each particle.
[8 marks]

Include the following in your discussion:

- the nature of each particle;
- the relative charge of each particle;
- the relative mass of each particle;
- the range of each particle in air; and
- a suitable material which can be used to test for each particle.

In this question you will be assessed on the quality of your written communication skills, including the use of specialist scientific terms.

Alpha _____

Beta _____

4 Body temperature is a physiological measurement taken by a medical practitioner to determine how well the body is functioning.

(i) What is normal human body temperature? [1 mark]

_____ °C

(ii) What is the temperature above which the human body can no longer stay alive? [1 mark]

_____ °C

(iii) A thermometer is a device which can measure body temperature.

The table opposite compares three different thermometers.

Complete the table to describe how each thermometer works, how to take a temperature reading and one limitation associated with its use. [6 marks]

Give a different limitation for each thermometer.

The first thermometer has been completed for you.

Write your answers in the blank boxes.

Thermometer	How it works	How to take a temperature reading	Limitation
Underarm digital thermometer	The electrical sensor changes resistance at different temperatures	Place under the armpit and wait for the thermometer to beep	The temperature measurement will be lower than core body temperature
Contactless thermometer			
Tympanic thermometer			

5 Thallium-201 and rubidium-82 are radiopharmaceuticals used routinely in nuclear medicine.

(i) State the type of radiation emitted by thallium-201.
[1 mark]

(ii) State two medical uses for thallium-201. [2 marks]

1. _____

2. _____

Rubidium-82 is routinely used in PET scans.

(iii) Discuss the use of rubidium-82 in PET scans.

In your discussion include the following: [6 marks]

- what the letters PET represent;
- how the rubidium-82 is administered to the patient;
- the name of the particle emitted during the radioactive decay of rubidium-82
- the process of annihilation; and
- how the radiation emitted during the PET scan is detected outside the body.

6 The heart pumps blood through a number of arteries in the body.

The carotid arteries are the major blood vessels that carry blood from the heart, through each side of the neck, to the base of the skull.

(a) (i) How many times does a normal heart pump in one minute? [1 mark]

(ii) Describe how an accurate and reliable value for heart rate can be measured from the carotid artery using a stop clock. [4 marks]

(b) Ultrasound can be used to check the carotid artery for blockages or narrowing.

(i) What is ultrasound? [1 mark]

(ii) Suggest a suitable **range** of frequencies to be used to obtain an image of the carotid artery. [2 marks]

_____ Hz

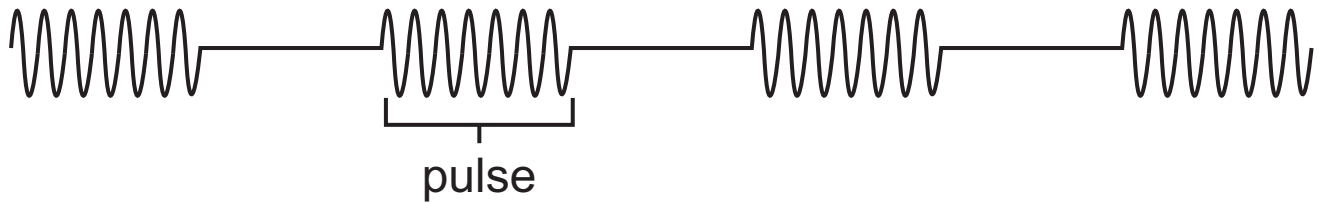
to _____ Hz

(iii) Why is the range of frequencies suggested in **(ii)** suitable for obtaining an image of the carotid artery? [2 marks]

(iv) Describe how a blockage in the carotid artery would be identified using the image observed in an ultrasonic B-scan. [2 marks]

- 7 Ultrasound waves are transmitted into the body using an ultrasound transducer probe.

The transducer produces short pulses of ultrasound.
This is shown in the diagram below.



- (a) (i) Explain why gel is placed between the transducer probe and the skin during an ultrasound scan. [2 marks]

- (ii) Explain in detail why the transducer probe is designed to produce pulses rather than continuous ultrasound waves. [4 marks]

(b) (i) Define specific acoustic impedance. [2 marks]

Ultrasound travels at a speed of 1.57 kms^{-1} in tissue A. The specific acoustic impedance (Z_A) of ultrasound in tissue A is $1.60 \times 10^6 \text{ kgm}^{-2}\text{s}^{-1}$.

(ii) Calculate the density of tissue A. [4 marks]
Include a unit with your answer.

Show your working out.

Density of tissue A = _____

Unit = _____

Ultrasound is transmitted from tissue A into a different body tissue B.

The density of tissue B is 1.29 times greater than that of tissue A.

The speed of ultrasound in tissue B is 2.68 times greater than in tissue A.

(iii) Calculate the specific acoustic impedance (Z_B) in tissue B. [2 marks]

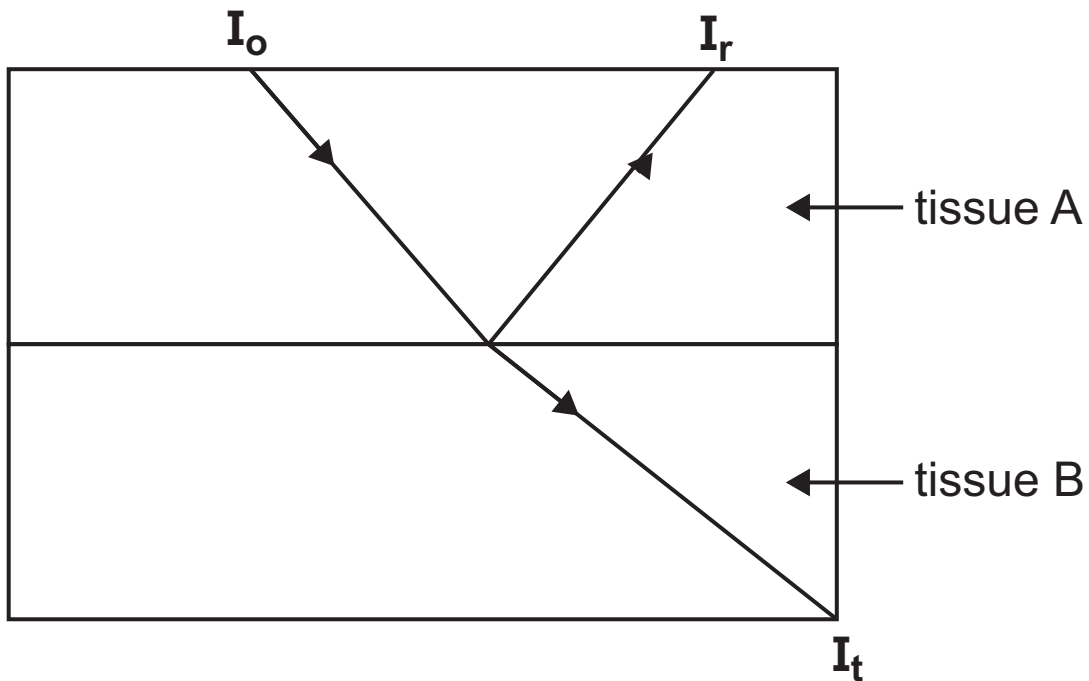
Show your working out.

Specific acoustic
impedance in tissue B = _____ $\text{kgm}^{-2}\text{s}^{-1}$

The diagram below shows what happens to the ultrasound at the boundary between the two body tissues.

I_o is the incident ultrasound intensity, I_r is the reflected ultrasound intensity and

I_t is the transmitted ultrasound intensity.



(iv) Write an equation which describes I_r in terms of I_o and I_t . [1 mark]

(v) Write an equation which describes the intensity reflection coefficient, R , in terms of Z_A and Z_B . [1 mark]

(vi) By first calculating the intensity reflection coefficient, R , determine the percentage of the initial intensity I_0 which is transmitted. [3 marks]

Show your working out.

Intensity reflection coefficient = _____

Percentage of ultrasound transmitted = _____ %

(iv) State two **man-made** sources of background radiation.

[2 marks]

1. _____

2. _____

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(Questions continue overleaf)

9 Americium-241 is a radioactive source used in smoke detectors.

The decay constant of americium-241 is $1.61 \times 10^{-3} \text{ yr}^{-1}$.

(a) (i) Write down the equation which shows the relationship between the decay constant and the half-life. [1 mark]

(ii) Calculate the half-life of americium-241. [2 marks]
Give your answer to three significant figures.

Show your working out.

Half-life = _____ yr

(b) The activity of a source of americium-241 was measured as 12.2 Bq.

(i) What is meant by the **activity is 12.2 Bq**? [2 marks]

- (ii) How many years would it take for the activity of this source to reduce by 10%? [5 marks]

Show your working out.

Number of years = _____

This is the end of the question paper

SOURCES

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Question Number	Marks
1	
2	
3	
4	
5	
6	
7	
8	
9	

Total Marks	
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Examiner Number

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